IMPROVING USER INTERFACES WITH HAPTIC FEEDBACK

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Outline

- Introduction
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  - Origins of haptic feedback
- Background
- Methods
  - Wearable Haptics
    - Older haptic gloves
    - The Kinect
  - Robotic Swarm Interfaces
    - Zooids
    - Ubiswarm
  - Mid-Air Haptics

Why Care About User Interfaces?

- Two billion computers on the planet
- The internet and other computer systems interwoven in most of the world's system, health to economics
- Average American spends 10 hours on some computer a day – 41% of your day!
- Improving interaction efficiency and making interactions more pleasant

Why Haptic Feedback?

- Audio, visual cues already used very effectively
- Sense of touch considered top sense
- As seen by touchscreens, people like touch-based interaction
- Natural next step: haptic feedback – helps us feel in touch

What is Haptic Feedback?

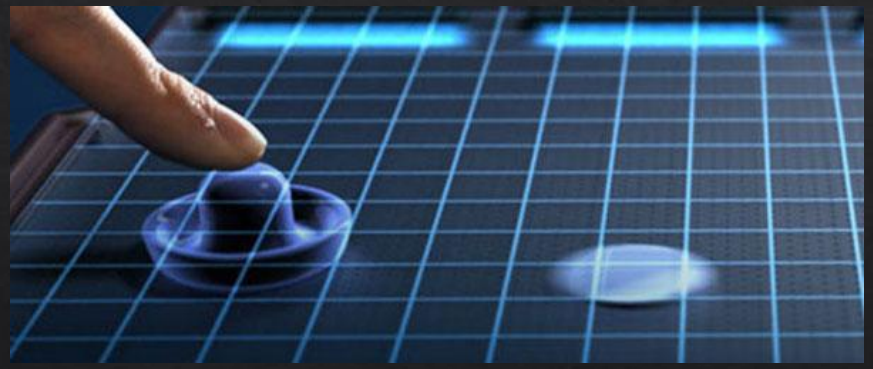
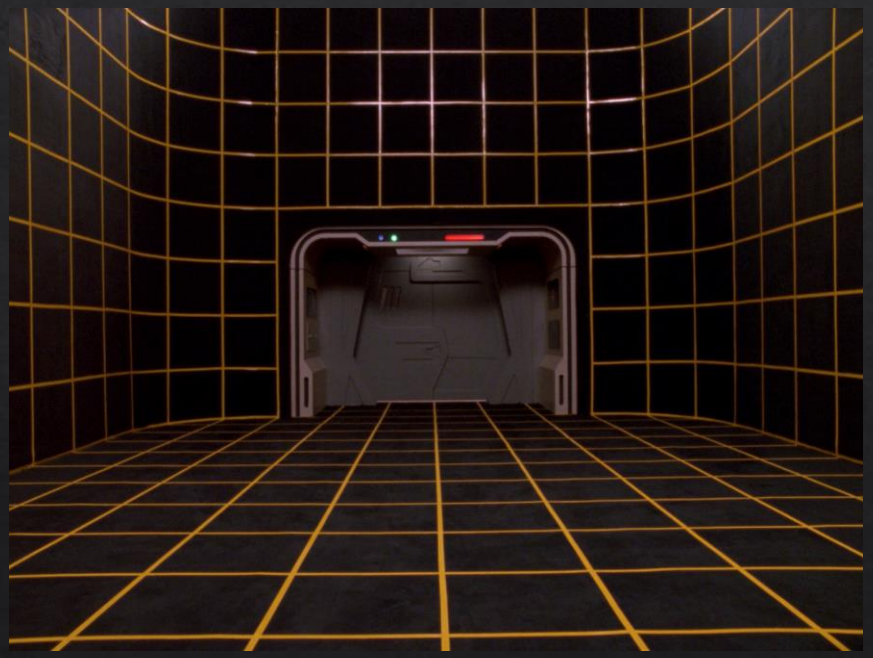


Image courtesy of Forbes

- Also known as “haptics”
- Simply put – Using the sense of touch to provide contextual information to the user
- Can include vibrational, kinetic, and non-contact (mid-air) feedback

Origins of the Idea: Haptics



- Lots of fantastical ideas from science fiction – Star Trek, Minority Report, etc.
- Haptic feedback gloves in the 90's (NES PowerGlove)
- Vibrative feedback in the early 90's in autos and vibrating theater chairs

Background – Common Examples

- Gaming systems – vibrational feedback on actions
- Airplanes – altitude and other indicators
- Appliance knobs – vibration on reaching different settings
- Electric toothbrush – cycle identifiers

Important Terminology

- **User interface (UI)**: A space where humans interact with a computerized system
- **Tactile feedback**: The same as haptic feedback
- **Limen**: A threshold below which stimulus is not perceived
- **Swarm user interface (SUI)**: A UI made of independent self-propelled elements that move collectively and react to user input

Methods: Short Summary

- Haptic Wearables
  - Gloves
  - Fingertips
- Swarm UIs
  - Zooids
  - UbiSwarm
- Ultrasound
  - Makino

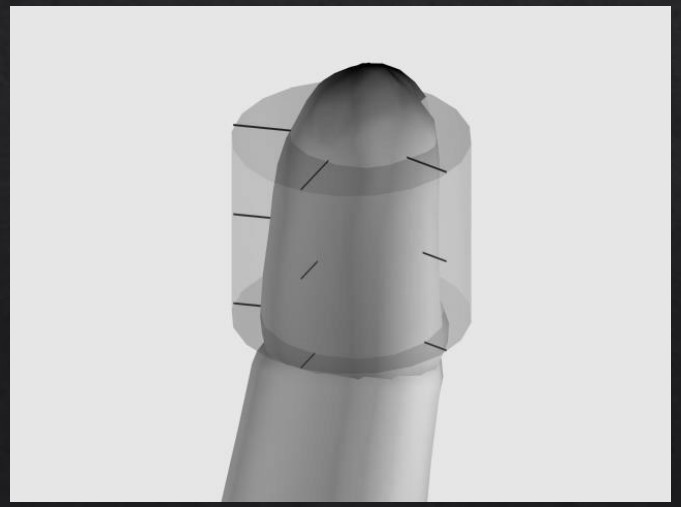
Methods – Wearable Haptics

- Many of the first haptic feedback devices were wearables – gloves, coats
- The first haptic feedback watch – called the Tap-in – was proposed in 1995, would not be realized for more than a decade

Methods – Wearable Haptics: Gloves

- 1999: Burdea et. Al. propose use of haptic feedback gloves
- At the time: Entire haptic arms in use, unwieldy and expensive
- Some gloves in use – hardware works well, algorithms need improvement

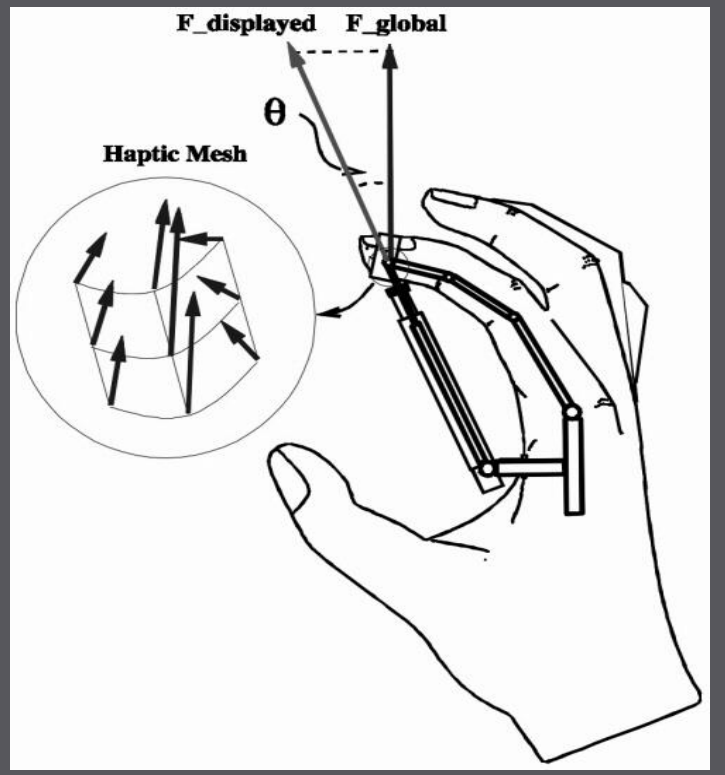
Methods – Wearable Haptics: Gloves cont.



- Burdea et. al. indicate important factors: force returned, surface deformation, weight
- Most important factor: Shape
- Shape is important both for device and feedback given

Methods – Wearable Haptics: Gloves cont.

If you're applying haptic feedback to a hand – do so in the shape of hand.



Past glove methods didn't use meshes – instead, small number of well placed haptic points.

Methods – Wearable Haptics: Gloves cont.

- Burdea emphasize use of meshes vs shortlist of haptic points
- Makes haptic feedback more versatile
- Case examples: Ball game, virtual putty

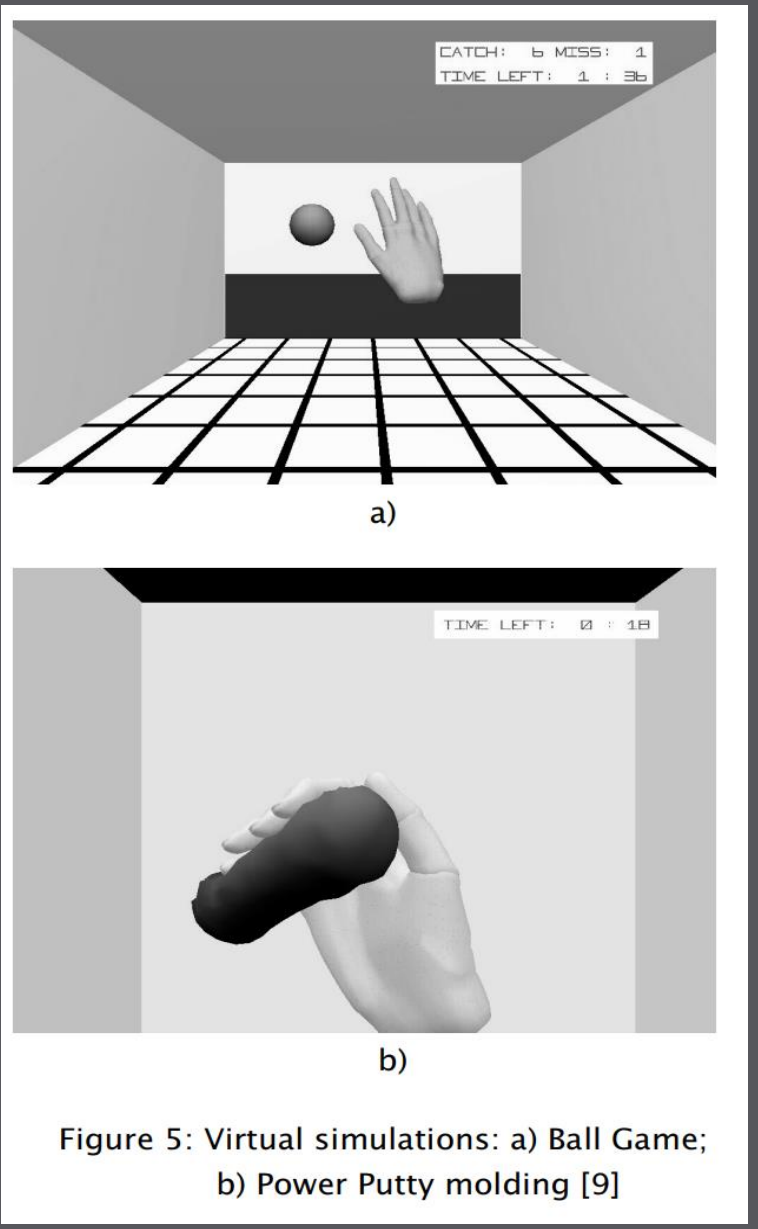


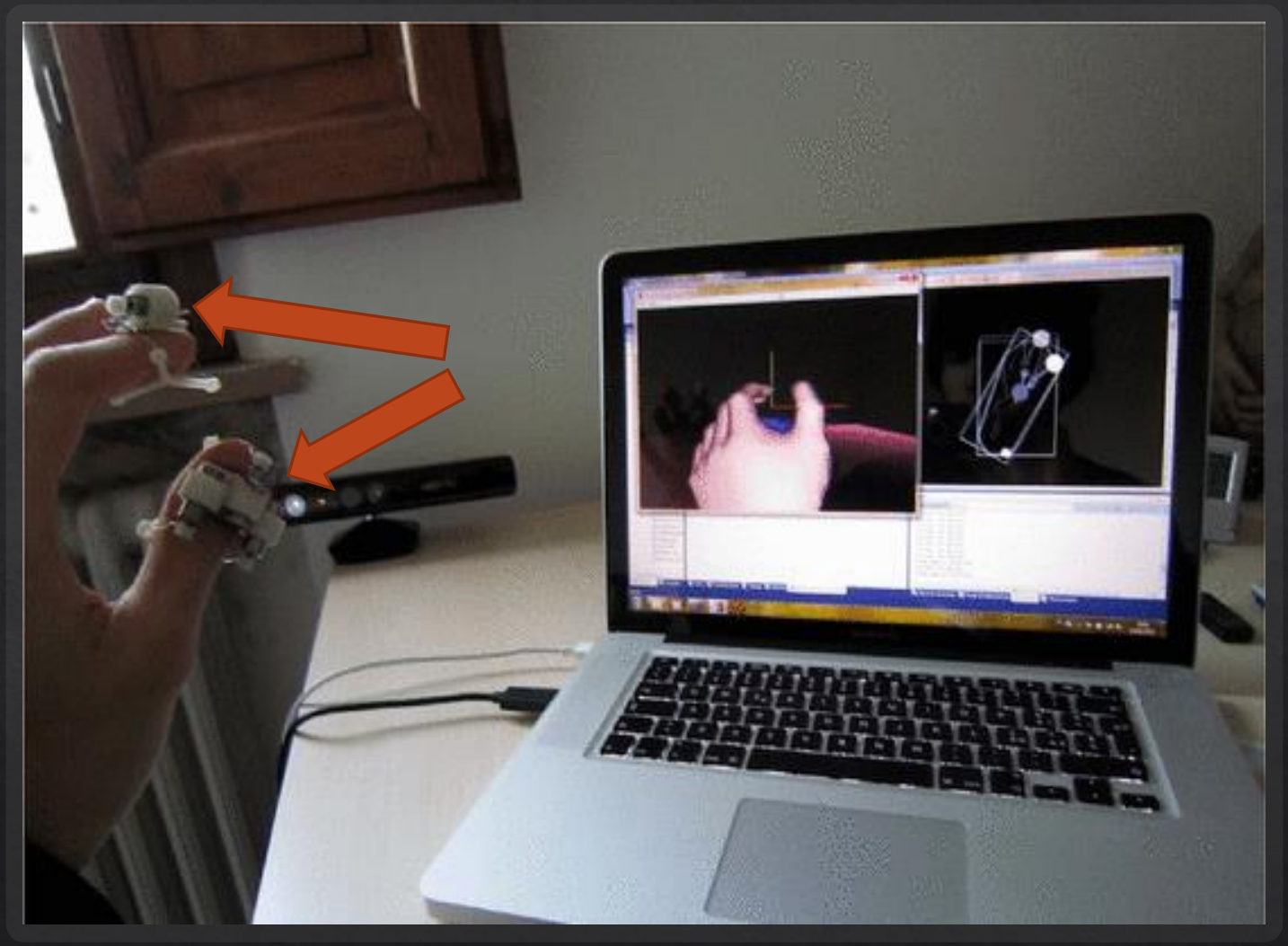
Figure 5: Virtual simulations: a) Ball Game; b) Power Putty molding [9]

Methods – Wearable Haptics: Fingertips

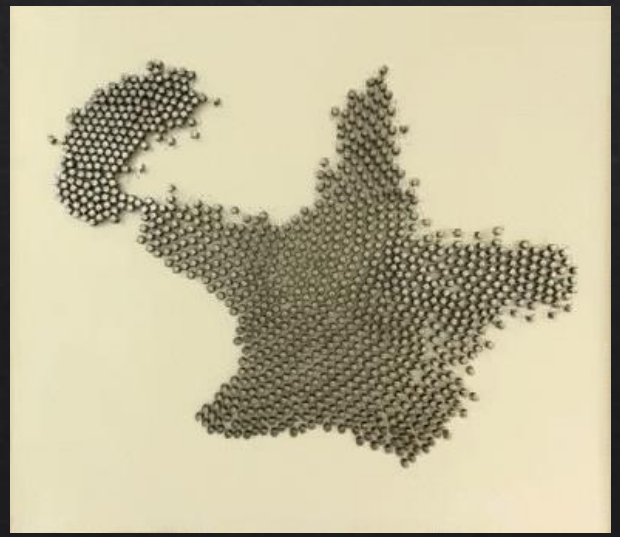
- Kinect: Motion tracker for Xbox from Microsoft
- Frati et. al. propose adding fingertip haptic feedback
- Note – contrary to suggestion by Burdea

Methods – Wearable Haptics: Fingertips

- Proposed system: Cutaneous feedback for the thumb and index finger
- Unable to provide kinesthetic resistance



Methods – Wearable Haptics: Swarm Interfaces



- Previously not feasible due hardware and computational costs
- Allow far greater environmental flexibility than gloves
- Limited feedback capabilities
- Dual purpose – both display and haptic feedback

Methods – Wearable Haptics: Swarm Interfaces cont.

- Zooids: First major prototype
- Constrained to horizontal surfaces
- Not very interactive

Methods – Wearable Haptics: Swarm Interfaces

- UbiSwarm: Based off Zooids
- Faster, more agile, magnetic for verticals
- Provide haptic vibrational feedback on touch, interaction
- Lights
- Capable of interacting with external world, moving objects

Methods – Wearable Haptics: Future Swarm Interfaces

- Stronger, faster
- Three-dimensional self-contained forms (Big Hero Six?)
- Sculpting
- Far out – forming, enhancing structures like walls

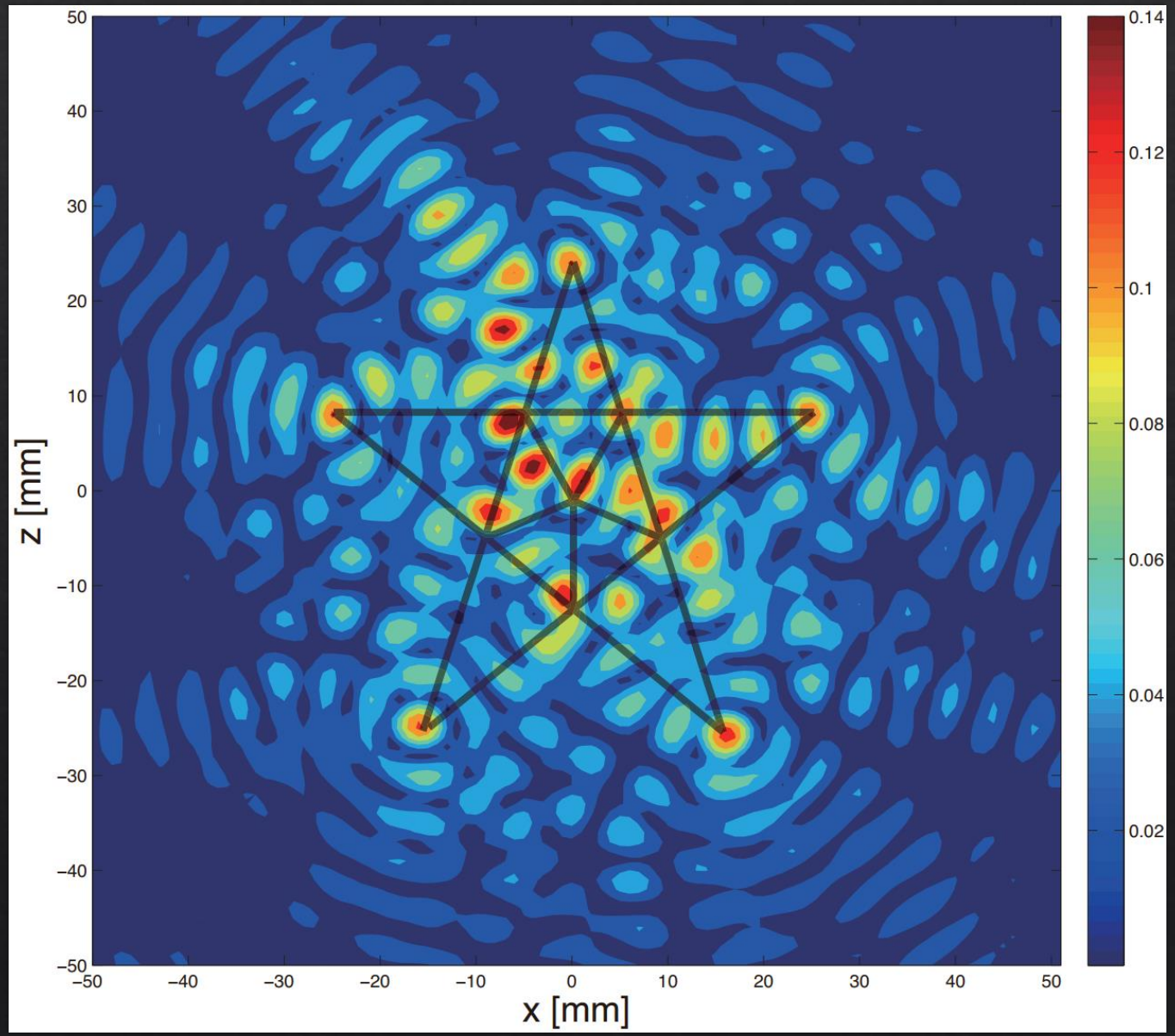
Methods – Ultrasound Haptics

- Ultrasonic – Greater than 22.1 kHz
- Actually tangible to the human sense of touch; sound waves = subtle vibrations
- No true application of force – sensation similar to wind

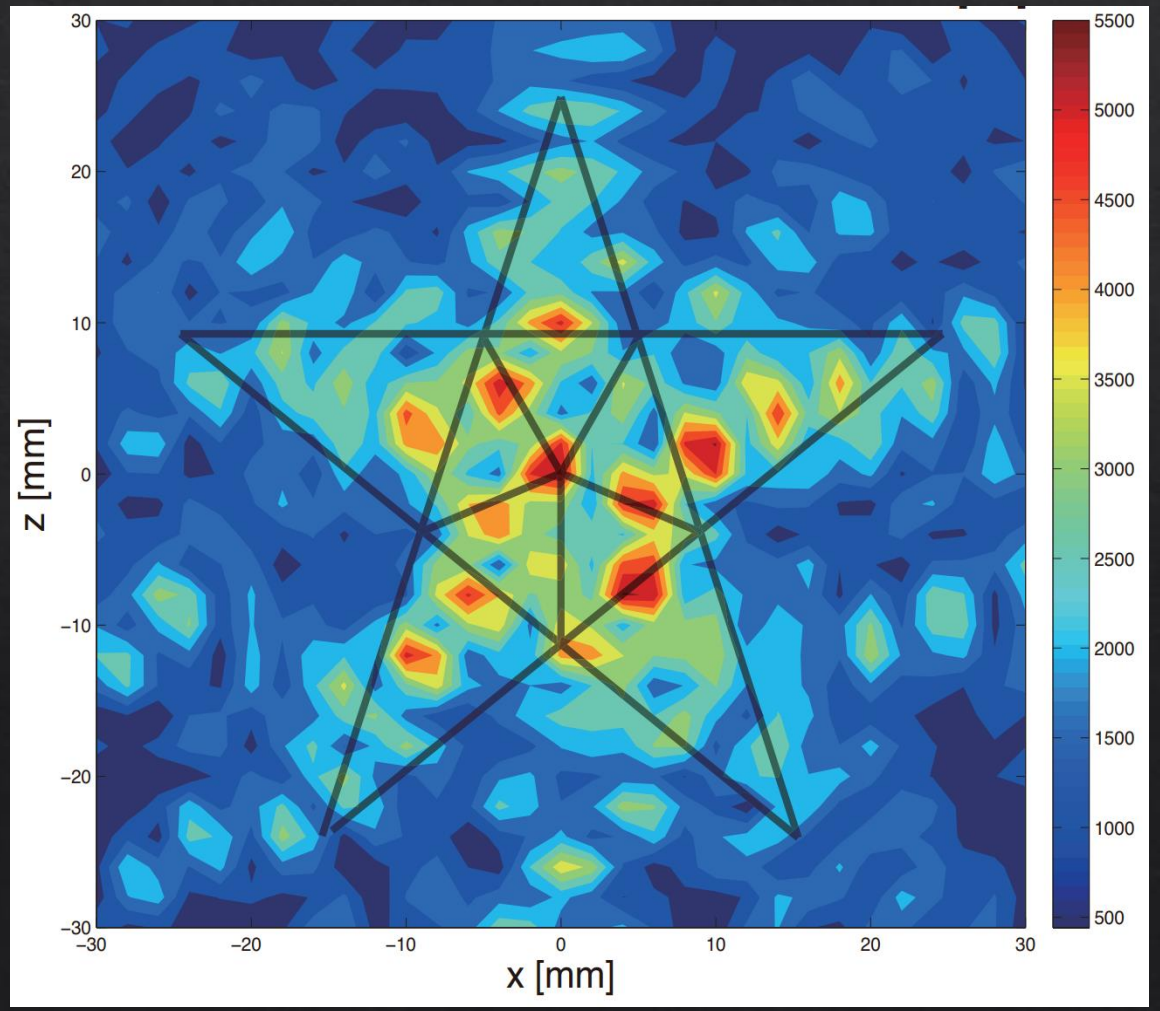
Methods – Ultrasound Haptics cont.

- Makino et. al: Interactive, mid-air ultrasonic waves good alternative to gloves: less constraints
- Propose octagonal array system for 6DOF, low detail shapes
- Pressure felt by user is non-linear to actual acoustic pressure – power required increases greatly

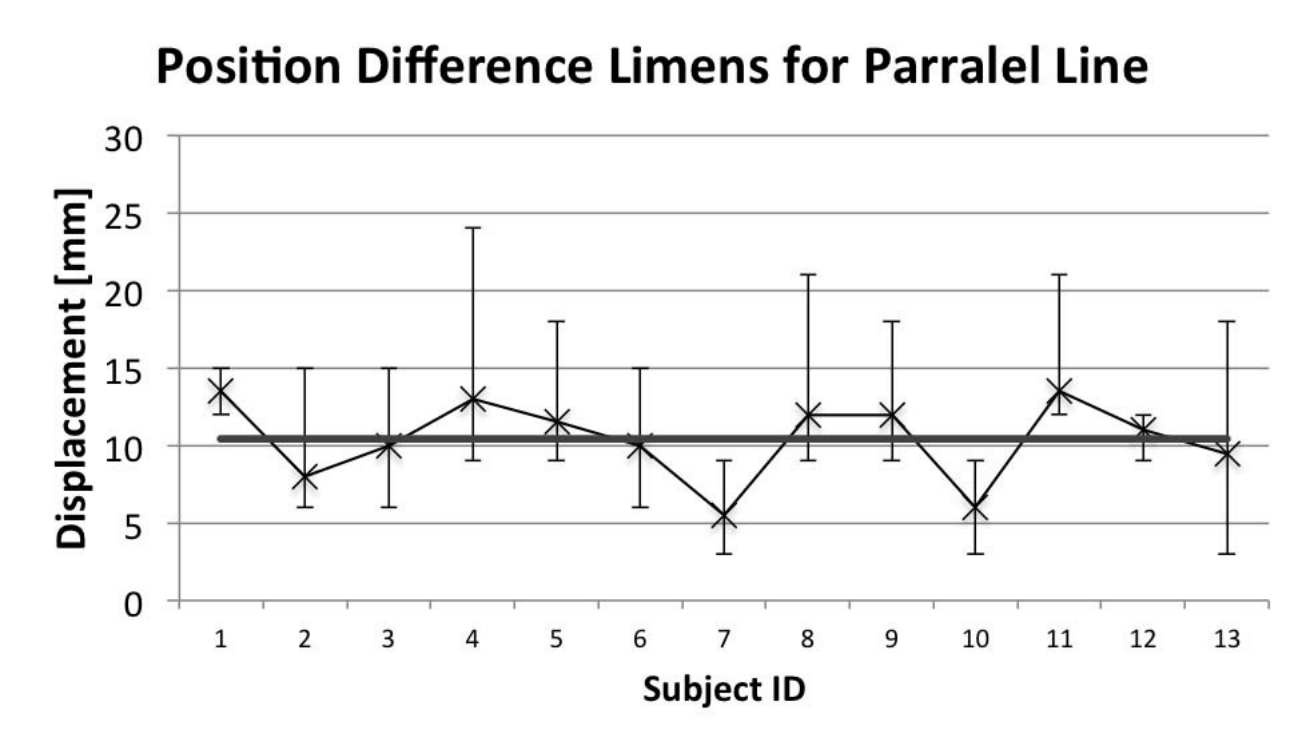
Ultrasonic Force Graphed



Left: Simulated pressure in a projected star shape.
Bottom: Actual measured pressure exerted projecting a star, 20% power.



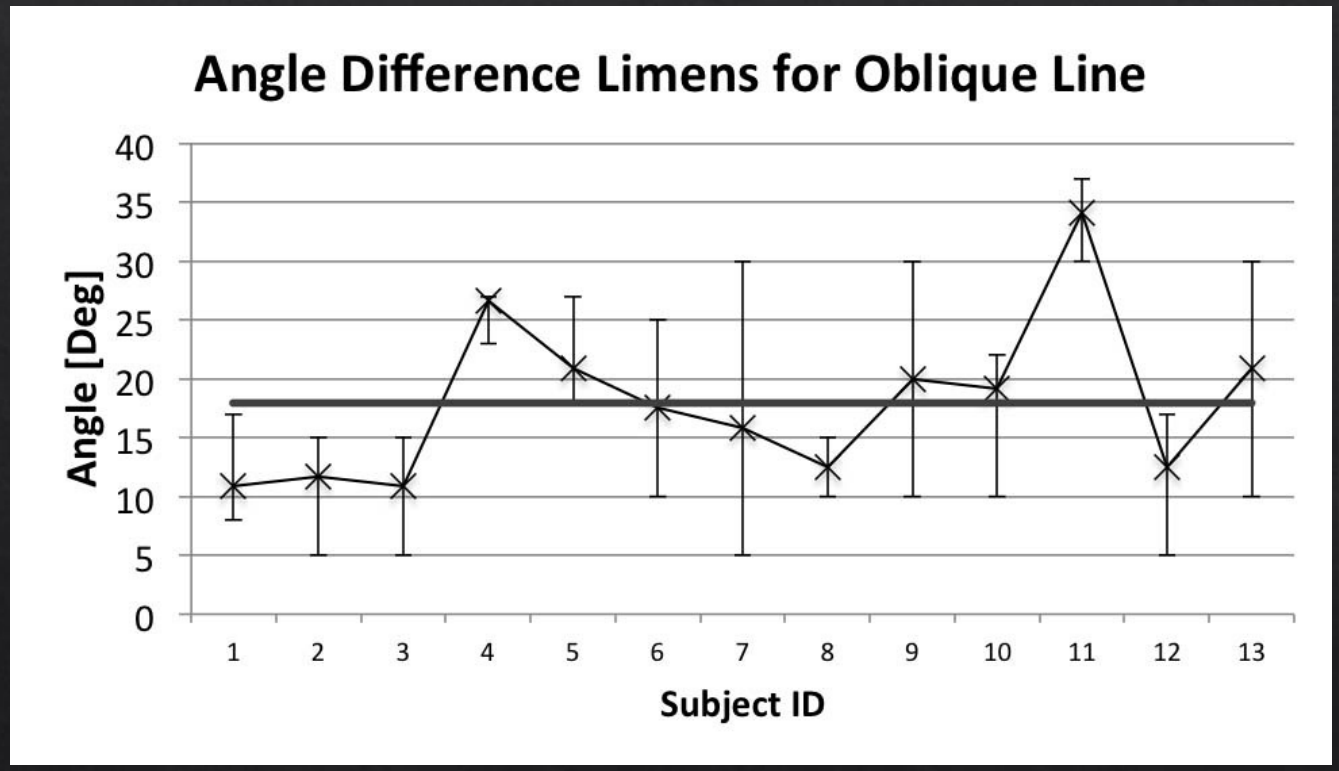
Ultrasonic Effectiveness Study



Makino et. al. study: 13 participants.
Part 1: Identify position of line.

Most participants clearly able to distinguish line despite mere 10mm width.

Ultrasonic Effectiveness Study cont.



Part 2: Identify position of line. Note participant ability varies greatly. #11 had trouble identifying shapes at all.

Methods – Ultrasound Haptics cont.

- Study shows great promise in general shapes
- As expected, details difficult

Conclusion

- All of the above technologies have pros and cons
- Wearables better in entertainment, industry
- Robotics better in flexible home/office environments
- Ultrasonic best for indoor appliances, light entertainment

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